Special Topics Course Information

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This is going to be a course on special topics on theoretical physics focusing on advanced quantum field theory. Our objective is to help a freshman Ph.D. student or a researcher to build his/her skills necessary to analyze ubiquitous phenomena arising from high energy or condensed matter physics through developing advanced tools coming from quantum field theory. The Steven Weinberg's brilliant book, i.e., The Quantum Theory of Fields (Volume 1, Foundations) provides us an excellent source of this course. Therefore, the instructors suggest attenders find this book somehow before they kick the course off. Below, we provide a sketch of those topics which we hope to cover collectively during the current semester:

1. **Relativistic Quantum Mechanics**
    - Quantum mechanics
    - Symmetries
    - Quantum Lorentz transformation
    - The Poincare algebra
    - One-particle state
    - Space inversion and time-reversal
    - Projective representations
2. **Scattering Theory**
    - "In" and "Out" states
    - The S-matrix
    - Symmetries of the S-matrix
    - Rates and cross-sections
    - Perturbation theory
    - Implications of unitarity
    - Partial-wave expansions
    - Resonances
3. **The Cluster Decomposition Principle**
    - Bosons and Fermions

- Creation and annihilation operator
- Cluster decomposition and connected amplitudes
- Structure of the interaction

4. **Quantum Fields and Antiparticles**
   - Free fields
   - Causal scalar fields
   - Causal vector fields
   - The Dirac formalism
   - Causal the Dirac fields
   - General irreducible representations of the homogeneous Lorentz group
   - General causal fields
   - The *CPT* theorem
   - Massless particle fields

The course will be held on Sundays and Tuesdays from 15:00 to 17:00 based on the platform (in person or online class) that the office of institute chooses. The course will have assignments galore and hence needs a great effort, however we'll end up each chapter with solving them. The classes start from Sunday, Mehr the 4^{th}.

It is possible that students from outside IPM takes the course as guest students. For that they have to coordinate with the office of school of physics, physoffice@theory.ipm.ac.ir.

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